Measurement of data centre power consumption

Everybody knows that data centres are becoming one of the major consumers of electricity in the industrialised world and the trend is set for it to rise even higher. The pressure is on in all countries to reduce energy consumptions in the IT sector but understanding where the power is going, and measuring it, is an essential start to the energy saving process.

It is estimated that 2% of all electricity consumption goes into information technology applications including data centres. In America that figure is already believed to have reached 2.8% of national electricity production. In energy consumption terms this is equivalent to the output of the aviation industry yet it has not been subject to the same public scrutiny.

This is starting to change. According to the European Union the energy consumption of data centres was 46 Terawatt hours in 2006 and is set to rise to 93 TWhr by 2020. This is the equivalent of one hundred million 100 watt light bulbs burning 24 hours a day, 365 days a year. In the US the figure has been given as 70 TWhr in 2007. The European Union has started work on the Data Centre *best practice guide* and in the US we have seen the introduction of *Server and Data Center Energy Efficiency, Public Law 109-431* requiring measures to be taken to improve efficiency and measure performance.

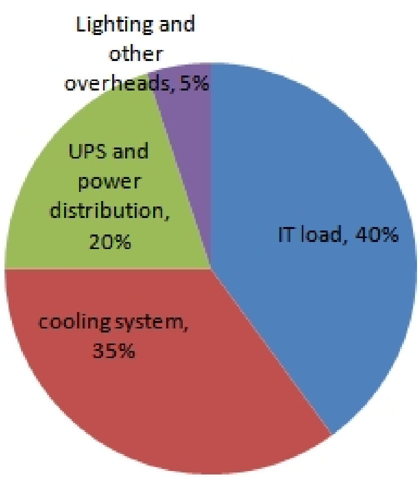
Various other laws in circulation like the *EU Energy Performance of Buildings Directive* require energy consumption to be measured down to a departmental or process level.

Qatar, Bahrain, Kuwait and the UAE already take four of the top five positions in the world for energy consumption per head of population but sometimes electricity production cannot keep pace with demand however energy-rich the country may be.

If we compare the average data centre with the average office we can see that that a data centre consumes around fifty four times more energy on a square meter by square metre basis. Each 600 x 600 mm floor tile on an average computer room floor represents the equivalent of 1.2 tonnes of carbon dioxide released into the atmosphere every year.

We now need to understand which processes are consuming the electricity in the data centre environment. The main processes are;

- The IT equipment load
- Cooling and ventilation
- UPS and power distribution overheads
- Lighting and other building overheads



A typical distribution of power consumption will be;

• The IT load	40%
• The cooling system	35%
• UPS and power distribution	20%
• Lighting and other overheads	5%

Virtually every watt expended in a computer room in the terms of processing power, power supplies, lighting etc is

turned into heat eventually. In a closed system, such as a computer room, this heat must be removed. If the outside air is even hotter than the computer room desired level then a great deal of energy will have to be expended to persuade large quantities of heat to be effectively pushed uphill and dumped outside.

For reasons such as this it can be difficult to exactly determine how much electricity is required to cool an energy intensive environment such a data centre. A survey of twelve American data centres revealed a spread of between 25 and 55% of the total energy consumption consumed by the cooling and ventilation system. The average figure was 35%.

The factors controlling the energy consumption of the cooling system depend upon

- The method of cooling, e.g. direct expansion DX, or centralised chiller
- The effectiveness of the design and installation
- Level of maintenance applied to the installation
- The external temperature
- The solar gain of the building
- The use of air or water economisers that take advantage of cooler conditions

The energy consumption itself goes mainly into the compressors but also in the numerous pumps and fans that drive the cooling system.

With such a large percentage of power consumed by the cooling system it is necessary to measure the energy consumption with a data logging system controlled and monitored by a Building Management System, BMS, that will record energy consumption by time, building zone, external temperatures etc. Apart from energy profiling and tuning the system for maximum performance any potential problems can be more easily identified and intercepted.

If one goes for the more advanced air or water side economisers then BMS control is essential. The very simplest air side economisers divert air from the outside when the external air temperature drops below about 20 C. Even in Dubai this would come into operation during the night time for about four months of the year. This would equate to between 10 and 15% reduction off the electricity bill.

The other major overhead is the UPS and power distribution system. The UPS, the Uninterruptible Power Supply, is traditionally a big consumer of energy. The most popular type is the on-line double conversion method. This takes in the mains voltage and converts it to direct current which is then available to charge the standby batteries. The DC voltage is then fed into an inverter which, via an output transformer, presents clean mains voltage to the IT load.

This method is popular because it completely isolates the load from the incoming supply and the direct connection of the inverter to the batteries means that the supply is never interrupted at all. The downside is that the ac to dc conversion, followed by a dc to ac conversion and then an output transformer is very inefficient. Typically 12 to 15% of the power arriving is lost as heat in the UPS, which must also be handled by the air conditioning. If the UPS is only lightly loaded then the level of inefficiency can be even worse.

Smaller systems now often opt for the transformerless version which runs more efficiently. Larger systems can go for a rotating kinetic energy system. This is much more efficient as it consists of a motor driving a generator. This acts a very efficient filter with only about 3% losses. The energy storage part comes from the kinetic energy of a large rotating mass connecting the motor and

generator. One downside to this approach is the hold-up time of such a system is only measured in tens of seconds as opposed to the many minutes available to the battery-backed system. But for large megawatt systems however the improvement in efficiency makes this very attractive.

All modern UPS systems now come with sophisticated software-based monitoring systems. These allow the phase loading of each UPS output to be measured over time. This information is vital to ensure that the phase loading on a three phase system is kept as evenly balanced as possible. This information can also help ensure that the UPS is kept operating within its ‘comfort zone’ of 20 to 80% of its rated capacity.

The final area to be measured is the power consumption to each rack. This can be done by simple LED ammeters in each power strip or more sophisticated addressable units. It is essential not to overload server racks with equipment because they must be tuned to the performance of the air conditioning systems. Four to six kilowatts per rack is a good average for an air cooled system and monitoring the power drain on each rack will enable the user to maximise use of floor space and power supply without creating hot spots that the air conditioning system will struggle to cope with.

Grant Sauls

Falcon Electronics Pty Ltd

www.fe.co.za